CONFIDENTIAL CLAIM RETRACTED
DATE: 5/16/13 AUTHORIZED BY:

QUESTION #9

Please provide the data and a discussion of the methods used to develop the radiation background values found on Page 19.

RESPONSE #9

The following are the values referred to:

"Numerous measurements over a number of years indicate that the background gamma ray exposure rate in the vicinity of the mine averages about 10-25 uR/hr."

"Based upon recent data acquired by Anaconda and its consultants, ambient background radon-222 concentrations range from about 0.42 to 1.1 pCi/l and background radium-226 soil concentrations range from 0.10 to 1.90 pCi/g. Radon-222 flux (exhalation) has ranged from 0.10 to 5.21 $pCi/m^2/sec$ in background areas."

The values cited are based on the following studies:

Gamma Ray Exposure Rate

1. A radiological assessment of Paguate Reservoir was conducted in October and November, 1980 by Eberline Instrument Corporation for Anaconda Copper Company. ("Report, Radiological Characterization of Paguate Reservoir at Laguna, New Mexico.") A copy of this report was previously submitted to U.S.G.S.

A direct gamma radiation survey was conducted in the vicinity of the reservoir area. Gamma readings were recorded on a 200-foot matrix grid across the reservoir in a north-south and east-west direction. Approximately 1,500 survey points were measured, utilizing Eberline PRS-1 portable scaler/ratemeters with SPA-3 NaI(Tl) two-inch by two-inch scintillation detectors. The same detectors height (one-meter) was employed to read the gamma radiation at each survey point. Multiple gamma readings were made at each location and the average value obtained from these readings recorded.

This study showed that the arithmetic mean and its associated standard deviation was 18.25 ± 6.54, indicating that with 68 percent confidence, 11.71 to 24.79 uR/hr represent the background range of all the readings in the Paguate Reservoir area.

2. A study of background radiation was conducted in 1973 at the L-Bar Uranium Mine and Mill for Sohio Petroleum Company and Reserve Oil and Minerals Corporation. Special weatherproof thermoluminescent dosimeter (TLD) packets containing high-sensitivity lithium fluoride chips were placed at 10 monitoring points on and around the project site. The TLD's were exposed for 30, 60 and 90 days and were then analyzed to determine the amount of radiation to which they had been exposed.

This study concluded that the mean background radiation level at the site was on the order of 140-170 mRem/year or 16-19 uR/hr.

This report is in the files of the New Mexico EID and is therefore a public document. Applicable pages of this report are appended as Attachment 9-1.

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RESPONSE #9 (Continued)

3. Measurements of gamma radiation were conducted during 1979 and 1982 by Anaconda personnel at the four gamma survey control grids shown on Plate 5.2-1 of the Reclamation Plan. An Eberline PRM-7 or Ludlum 12S portable scintillation-type survey meter was used and readings were taken at one meter above ground surface.

Attachment 9-2 summarizes this data which shows exposure rates ranging from 5-15 uR/hr with averages at four sites ranging between 8-12 uR/hr.

Ambient Radon-222 Concentrations

Ambient background radon-222 levels cited in the Reclamation Plan are the average concentrations determined during June, 1976 by Eberline Instrument Corporation in samples obtained in the vicinity of the Jackpile-Paguate Mine and presented in the U.S. EPA publication "Ambient Airborne Radioactivity Measurements in the Vicinity of the Jackpile Open Pit Uranium Mine, New Mexico" (January, 1979). A table summarizing this data is appended as Attachment 9-3. All of the locations noted in the table with the exception of "Jackpile Mine - Company Housing Area" are probably sufficiently distant from the influence of mining activities to be considered "background." The ambient radon-222 levels observed at these sites ranged from less than 0.12 to 2.7 pCi/l and averaged 0.42 to 1.3 pCi/l at the 10 background sites.

The statement in the Reclamation Plan did not include the ranges and averages determined by Anaconda's in-house monitoring although summaries of this data have been submitted to U.S.G.S. on August 19, 1979 and February 10, 1981 as well as in response to Question #4. The sites at which this data was collected have all been influenced to some extent by mining activities and the levels, therefore, are not truly representative of "background."

From February, 1979 through July, 1980 one 48-hour sample was taken monthly at each of the four air monitoring stations indicatred on Plate 5.2-1 of the Reclamation Plan. These samples were collected in 30-liter Tedlar bags using a modified aquarium pump, transferred to a scintillation cell, and counted using EPA-approved methods. Sampling height was approximately one meter above the ground.

Since August, 1980, ambient radon-222 levels have been determined by Ebeline Instrument Corporation RGM-2 units set up at each of the same four sampling locations. These units provide continuous radon monitoring with hourly printouts and a 24-hour average. The 24-hour averages are recorded on a summary sheet for each month and a monthly average is calculated for reporting purposes.

The Anaconda data, summarized on Attachment 9-4, indicates that from February, 1979 through September, 1980, average monthly ambient radon levels ranged from 0.01 to 1.90 pCi/l and generally averaged less than 1 pCi/l. From October, 1980 through December, 1981, average monthly levels ranged from 0.72 to 3.68 pCi/l and averaged about 2. The increase during the latter priod is undoubtedly due to a change in analytic methodology rather than change in ambient radon levels per se. Data obtained from the RGM-2 units is thought to be more reliable.

RESPONSE #9 (Continued)

Radium-226 Concentrations in Background Soils

During 1979, Anaconda obtained surface soil samples at 23 sites in the vicinity of the Jackpile-Paguate Mine which wrere thought to be representative of background soils. Soil samples were oven-dried, pulverized and a sample of the -100 mesh portion subjected to nitric-perchloric-hydrofluoric acid digestion. The leachate was further treated and radium-226 concentration determined by 20-minute counts in an alpha particle gas flow proportional counter as described in the procedure appended as Attachment 9-5. As shown on Attachment 9-6, the radium-226 levels ranged from 0.10 to 1.90 pCi/g and averaged 0.41 pCi/g.

Background Radon-222 Exhalation Rates

Radon flux determinations were made at several background sites by Anaconda during late 1978 and 1979. The method used was a modification of the Bernhardt technique as described in Attachment 9-7 and consisted of determining flux from radon and progeny activity measurements of samples withdrawn from a modified 55-gallon drum sealed into the ground.

The results of these flux determinations, summarized in Attachment 9-8, show rates ranging from less than 0.10 to 5.21 $pCi/m^2/sec$ and averaging 2.01 $pCi/m^2/sec$ for the 22 samples.

ATTACHMENT 9-1

Project 73-634

APPLICANT'S ENVIRONMENTAL REPORT

L-BAR URANIUM MINE and MILL

— VALENCIA COUNTY, NEW MEXICO —

Proposed by · SOHIO PETROLEUM COMPANY

and RESERVE OIL AND MINERALS CORPORATION

Albuquerque, New Mexico

August 1974

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2.9 BACKGROUND RADIOLOGICAL CONDITIONS

Since much of the public concern over the proposed project's environmental impact may focus on its potential release of radioactive materials, it was important to establish baseline information on background radiation levels and concentrations of radioactive materials. Field exposure measurements have been made; and soil, plant, small animal, and water samples collected on the site and in the surrounding vicinity have been analyzed. Results indicate that this area has levels that are typical of this part of the state but higher than the United States on the whole. This situation is as would be expected. The site area is at an elevation of 6200 to 6500 ft and receives considerable radiation from cosmic rays. Further, the rock and soil of this general locale contain a comparatively high concentration of radioactive materials - hence its exploitation as a principal source of the nation's uranium. The presence of such materials in the rock and soil accounts for their presence in water, air, and biota. Although it is possible that man's activities in exploring and mining for uranium at several nearby locations has raised the background level somewhat, it is believed that the levels have changed little over many years.

RADIATION LEVELS

Background radiation from all sources was measured in the field by means of thermoluminescent dosimetry techniques. Special weatherproof thermoluminescent dosimeter (TLD) packets containing high-sensitivity lithium fluoride chips were placed at 10 monitoring points on and around the project site. These TLD's were exposed for 30 days, 60 days, and 90 days at the sites indicated on Figure 2.9A, and were then analyzed to determine the amount of radiation to which they had been exposed. Exposure data for all 30 TLD packets are presented in Table 2.9A. An extrapolation of the measurements made over three months of exposure indicates that the mean background radiation level at the site is on the

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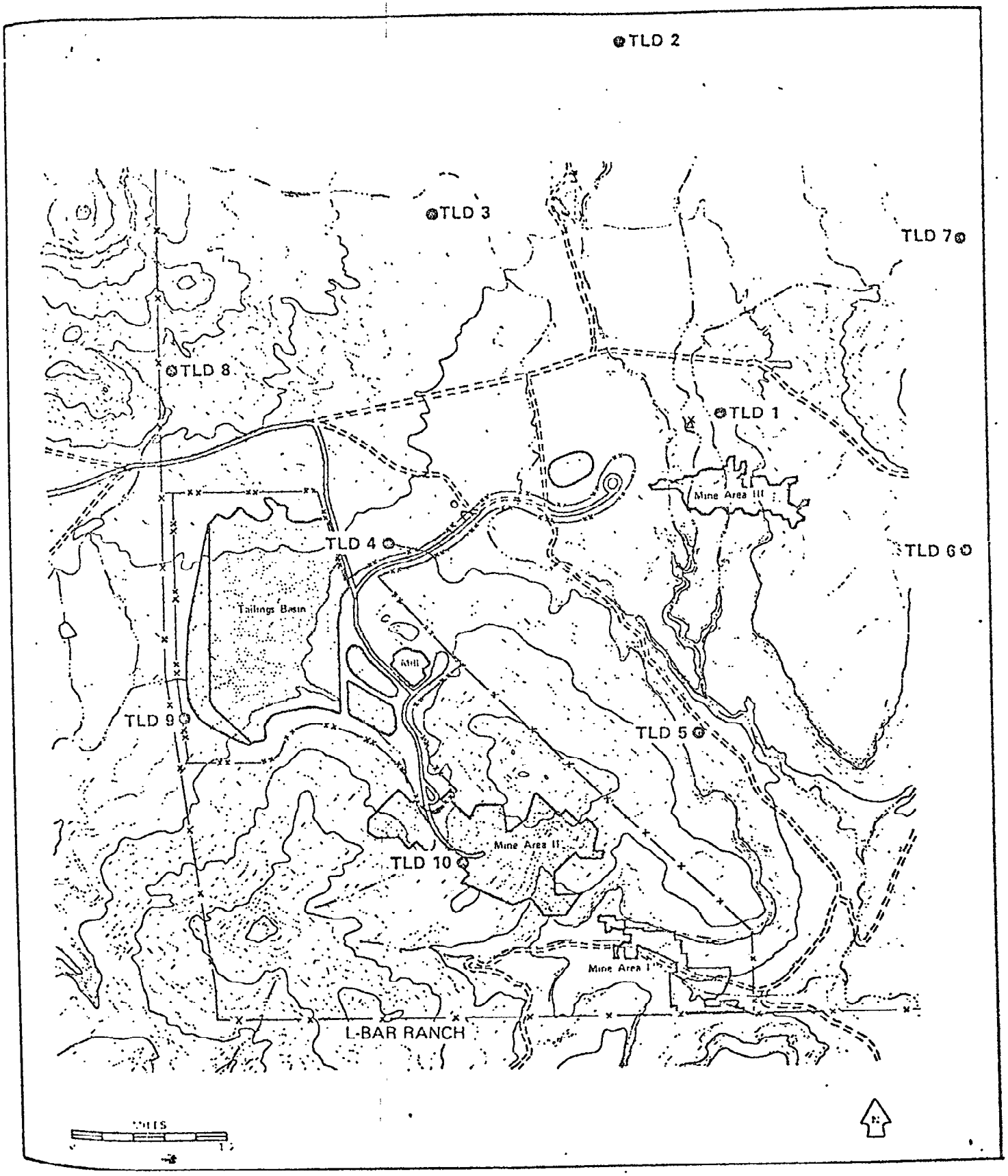

Figure 2.9A. THERMOLUMINESCENT DOSIMETER EXPOSURE SITES

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Table 2.9A. BACKGROUND RADIATION LEVELS AS MEASURED BY THERMOLUMINESCENT DOSIMETERS

Sites*	Radiation Exposure (mRem)			Annual**
	30 days	60 days	90 days	
TLD-1	15	21	37	149
TLD-2	13	25	44	175
TLD-3	13	24	40	161
TLD-4	12	20	34	135
TLD-5	13	25	36	146
TLD-6	13	22	31	124
TLD-7	14	29	39	157
TLD-8	11	23	31	124
TLD-9	10	21	35	139
TLD-10	10	29	31	124
			Mean:	143

*See Figure 2.9A for TLD exposure site locations.

**An extrapolation based on the 90-day exposure results

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order of 140 millirems (mRem)* per year. This computed level seems lower than would be expected from local geology and topography. Hence, a value of 170 mRem per year has been used as the background exposure rate in other computations in this environmental report.

RADIOACTIVE MATERIALS

Air

Airborne radioactive materials in the site vicinity are in the form of dust and radon gas. The dust could come from surface soil and rock that contain radioactive materials from other mining or exploratory operations in the vicinity or from radon daughter products. Particles therefore vary from sand and silt sizes (given high winds which occur commonly) down to molecular sizes. Actually, the very fine solid radon daughters normally form using a larger nonradioactive dust particle as a nucleation site and therefore do not behave like the aerosols. The radon present in the ambient air at the site is a decay product of radium in native soil and rock.

Background levels of airborne contaminants were measured three times on the project. High-volume air filters, drawing 50 to 60 cu ft per minute through membrane filters, were run 3 to 3.5 hours consecutively on three occasions. The particulate matter retained on the filters was analyzed for its radiological properties. Table 2.9B presents the results, and Figure 2.9A indicates the sampling locations. Samples were collected under a variety of climatic conditions.

---

*One millirem is defined as that quantity of any type of ionizing radiation which, when absorbed by man, produces an effect equivalent to the absorption by man equal to 0.001 of a roentgen of x-ray or gamma radiation (400 KV).

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ATTACHMENT 9-2

GAMMA RAY EXPOSURE RATES
ON CONTROL GRIDS
JACKPILE-PAGUATE MINE AREA

Gamma Survey Control Grid	Date	Number Of Measurements	Levels in uR/hr	
			Average	Range
North Lease	3/23/79	20	9.7	8-11
North Oak Canyon Mesa	3/20/79	17	7.9	5-9
Northeast Lease Corner	1/8/79	17	9.5	8-11
Northwest Lease Area	5/82	15	13.2	11-15

Environmental Protection
Agency
P.O. Box 15027
Las Vegas NV 89114

Radiation

EPA

Ambient Airborne Radioactivity Measurements in the Vicinity of the Jackpile Open Pit Uranium Mine New Mexico

ATTACHMENT 9-3

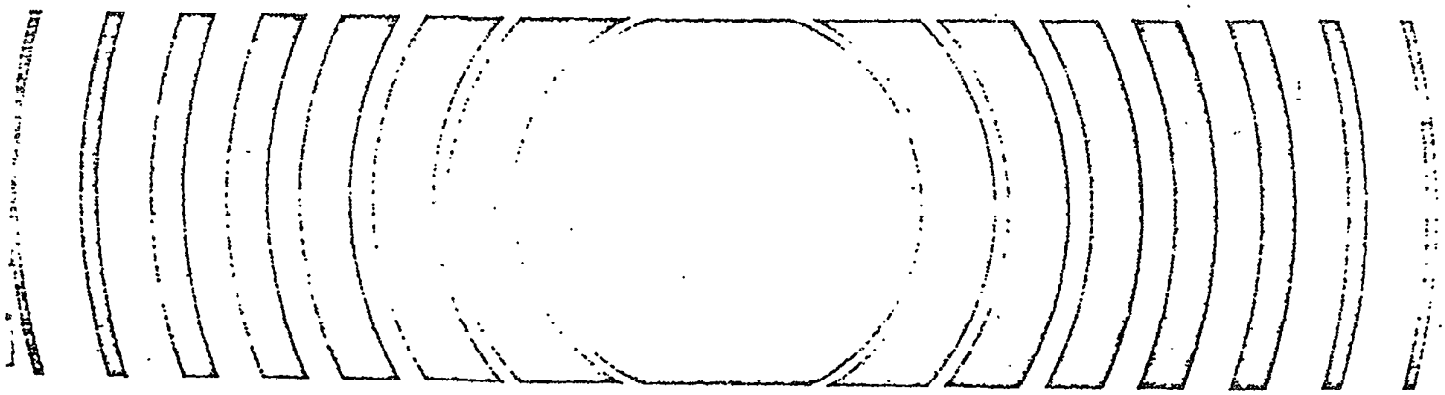

TABLE 2. AMBIENT OUTDOOR RADON-222 CONCENTRATIONS (in pCi/l)* DURING JUNE 1976 IN THE VICINITY OF THE JACKPILE OPEN PIT MINE, NEW MEXICO

Location, Description	Maximum Concentration*	Minimum Concentration*	Average Concentration**
Old Laguna-(#1)	1.3 ± 0.18	0.20 ± 0.10	0.51 ± 0.28
Laguna-Training Bldg. (#2)	1.5 ± 0.39	0.14 ± 0.07	0.51 ± 0.29
IHS-Laguna Health Center	1.6 ± 0.19	0.22 ± 0.11	0.63 ± 0.36
Bibo-Wellhouse	1.4 ± 0.29	Less than 0.12	0.50 ± 0.23
Mesita-Industrial Plant (#1)	0.89 ± 0.33	0.18 ± 0.05	0.47 ± 0.31
Mesita-Community Building (#2)	1.7 ± 0.22	Less than 0.12	0.55 ± 0.49
Moquino-Private Residence	1.4 ± 0.23	Less than 0.12	0.54 ± 0.31
Paguate-Community Building	0.74 ± 0.06	Less than 0.12	0.42 ± 0.14
Jackpile Mine-Company Housing Area	1.8 ± 0.23	0.25 ± 0.10	1.1 ± 0.34
Railroad Trestle (#1) Below Jackpile housing area	2.1 ± 0.26	Less than 0.12	0.99 ± 0.54
(Location #2)-One mile south of Railroad Trestle (#1)	2.7 ± 0.24	0.44 ± 0.05	1.3 ± 0.50

{ Excluded Influenced by Mining

* Source of Analyses: Eberline Instrument Corporation, Albuquerque, New Mexico
Result ± Two-Sigma Counting Error Terms

** Average Result ± Two-Standard Error Terms (i.e., standard deviation of the sample population divided by the square root of the number of samples)

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ATTACHMENT 9-4

AMBIENT RADON-222 LEVELS (pCi/l)
AT MONITORING STATIONS IN VICINITY
OF JACKPILE-PAGUATE MINE

Sample Location	Feb.'79-June '79 Range	July '79 - Sept.'80 Range	July '79 - Sept.'80 Average	Oct. '80 - Dec. '81 Range	Oct. '80 - Dec. '81 Average
Dump F	0.68 - 0.88	0.06-2.01	0.74	1.30-3.14	2.07
Mine Vent (P-10)	0.36 - 0.59	0.10-1.56	0.71	0.72-3.68	2.10
West Gate	0.56 - 0.72	0.06-1.90	0.62	1.13-2.17	1.48
Well #4	0.21 - 0.32	0.01-1.13	0.32	0.90-2.78	1.98

ATTACHMENT 9-5

RADIUM 226 DETERMINATION

(Public Health Service Method[1])

Introduction:

This procedure is set up primarily for assaying Radium 226 in water samples. However, if analysis of organic or solid sample is necessary this procedure is to be preceeded by the digestion outlined in Leaching Method of Digestion.

Range:

.001 pico curies/l to 1000 pico curies/l

Apparatus:

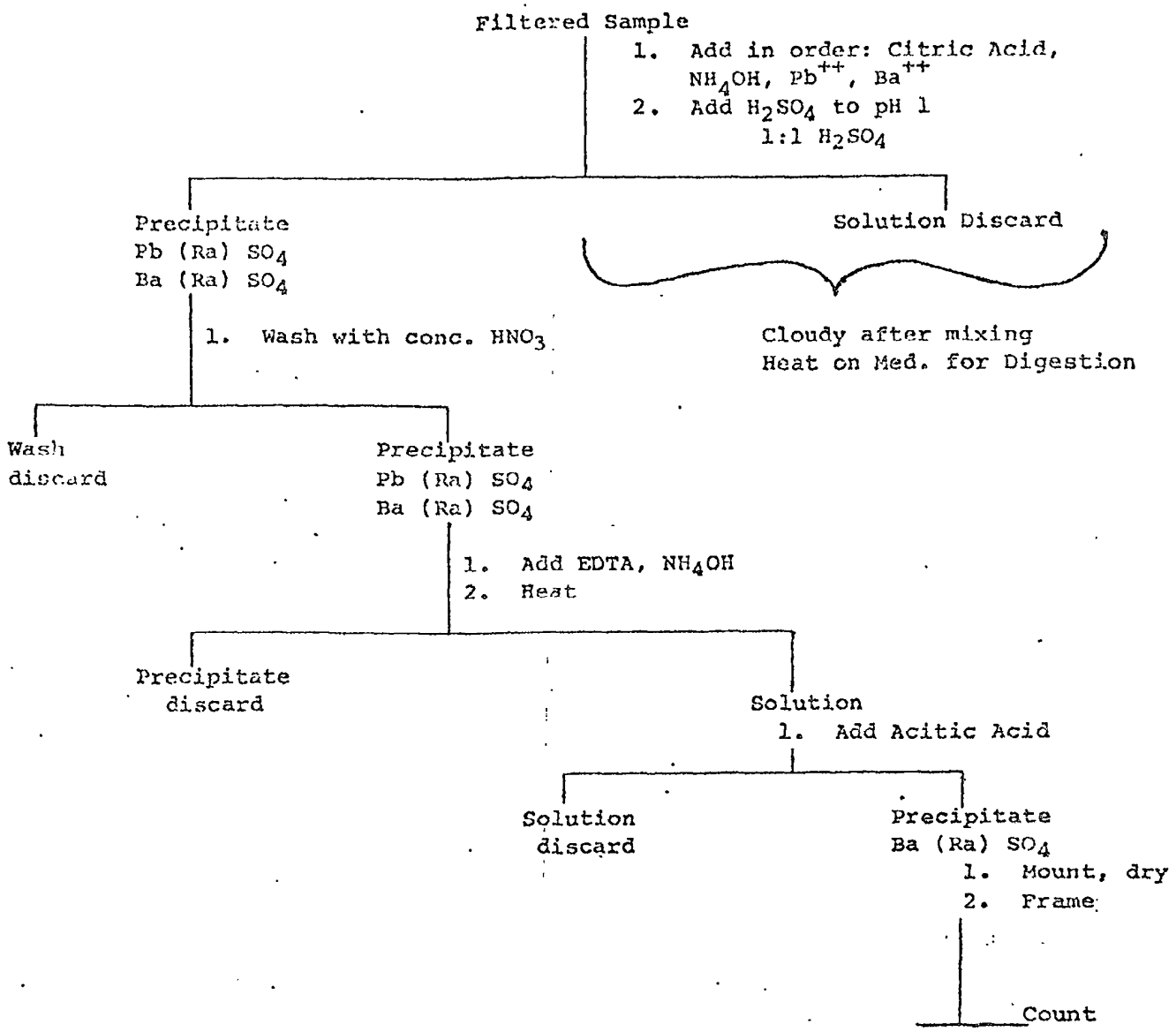
1. Alpha Counter
2. Centrifuge
3. Infra Red Lamp
4. Metal Planchets

Reagents:

1. Citric Acid 1 M: 210.01 gms/l
2. Lead Nitrate, Pb $(NO_3)_2$, 1 N: 210 gm/liter
3. Barium Nitrate, Ba $(NO_3)_2$, 0.1 N: 13.07 gm/liter
4. Sulfuric Acid, H_2SO_4 1:1 (vol/vol)
5. 0.25 M EDTA: 93 gm/l disodium salt (dihydrate)
   1 liter H_2O (add 5-10 ml NH_4OH to facilitate solution)
6. 6 N NH_4OH, 100.7 ml/250 ml
7. Methyl orange dissolve .05 g in 100 ml distilled water.

[1]Goldin, A.S., "Determination of Dissolved Radium", Manuscript, Robert A. Taft Sanitary Engineering Center, U.S. Public Health Service, Cincinnati 26, Ohio.

Flow Diagram of Procedure:



Procedure:

A. 1. To a 500 ml sample of filtered water*, add in order, while stirring:

.5 ml	1 M Citric Acid
2.5 ml	Conc. NH_4OH
2 ml	1 N $Pb(NO_3)_2$
1 ml	0.1 N $Ba(NO_3)_2$

*Tailings samples: use 100 ml of filtered sample.

2. Heat to boiling; while stirring, add 10 drops methyl orange and add 1:1 H_2SO_4 until a pink color is attained, then add 0.25 and in excess. (Total 2 ml).

3. After stirring for about 20 minutes, remove the stirring bar and allow the samples to stand over-nite, or until completely clear.

4. Decant most of the solution then centrifuge the remaining solution in 50 ml centrifuge tubes; discard supernate.

5. Wash twice with 10 ml HNO_3 washes, discarding the wash.

6. Dissolve the precipitate in 10 ml water, 10 ml EDTA solution and 3 ml of 6 N NH_4OH solution adding the solutions in the order above. Mix until ppt. is in solution.

7. Three (3) hours before counting, add 2 ml of Glacial Acetic Acid (slowly). If no ppt is formed, add 2 more ml Acetic Acid. If no ppt is formed, add 5 ml of 50% $(NH_4)_2SO_4$.

8. One (1) hour before counting, centrifuge and discard supernate. Wash with 15 ml distilled water, centrifuge and discard wash.

9. Transfer ppt to a clean planchet and dry under an infrared lamp.

10. Heat the planchet red hot on a Bunson Burner 3 minutes before counting.

11. Count for 20 minutes in the Gas Flow proportional counter. Repeat this step once.

Standard Preparation:

A 25 pCi/l stand. is usually used. To prepare the standard, dilute 0.25 ml of an 0.1 uCi/ml standard solution to one (1) liter. After mixing, the standard is treated exactly as a water sample.

At least 2 standards are run with each set of samples.

Calculations:

The method used to calculate the Ra-226 value from the Alpha counts determined in this procedure is written on a TI-59 Program Card. The program record is included with this procedure.

PROGRAMMER PL DATE 3-27-81 **Program Record**

Partitioning (Op 17) [ ] Library Module NO Printer Yes Cards 1

PROGRAM DESCRIPTION

Calculation of Ra-226 using A.S. Golden Procedure.

2 std cts, 2 samp cts after 3 hr
2 std cts, 2 samp cts after 168 hr
} time factor can be changed

1σ standard deviation calculated.

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS			DISPLAY
1	Initialize program	LBL A	2nd	LBL	A	Enter Blk.
2	Enter Blk.	Blk cpm	R/S			Enter Vol.
3	Enter Vol.	Vol in ml	R/S			Enter fst std
4	Enter First std cts	Std in cpm	R/S		R/S	Enter Sec cts
5	Enter Sec std cts	"	R/S		R/S	Enter fst cts
6	Enter First sample cts	Sample in cpm	R/S		R/S	Enter Sec cts
7	Enter Sec sample cts	"	R/S		R/S	Calculating
8	Calculation of results					Answer in uCi/ml
9	Calculation of 1σ SD					value of std dev.
10	Results to LBL B go to step 6 in procedure	Fst cts Sec cts	R/S R/S		R/S R/S	

USER DEFINED KEYS	DATA REGISTERS (INV STO)		LABELS (Op 08)
A Initialize	0 std cts-Bkg.	0 Bkg in cphr.	
B Reset to sample cts	1 3hr sample ctr	1	
C	2	2 7 day sample cts	
D	3 3hr factor	3	
E	4	4	
A'	5	5	
B'	6 sample vol. factor	6	
C'	7 7 day factor	7	
D'	8	8	
E'	9	9	

FLAGS	0	1	2	3	4	5	6	7	8	9

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1014966

RADIUM ANALYSIS DATA SHEET
A.S. G' DEN

Background Count: ____ ____ ____ ____
Average Background Count: ____
Counting Time: ____
Background Counting Rate: ____
Volume of Sample: ____

Analyst: ____________
Date: Set-up: ________
First Reading: ________
Second " " : ________
t_2= ________ days

le r	Sample Date	Description or Source	Final Ppt. Date	Final Ppt. Hour	Counting Time	Counted Date	Counted Hour	Total Counts		Results uCi/ml	Results pCi/L
5											
7											

The Anaconda Minerals Company

New Mexico Operations

PREPARATION OF SOIL SAMPLE

1. Approximately 200-250 grams of a soil sample is placed on a tray and placed in the oven for ± 14 hours. The oven is set at 175 °F.

2. The sample is then allowed to cool. Take the sample and run it through a Jaw Crusher and then a splitter.

3. The soil sample is then mixed thoroughly, and then placed in a pulverizer.

4. After the soil sample has gone through the pulverizer(-100 mesh) it is then placed on rolling paper and again it thoroughly mixed.

5. The soil sample is then placed in a sample bag and properly labeled and dated.

ACID LEACHING METHOD OF DIGESTION

1. Weigh out approximately 2 grams of solid sample and place in a 250 ml beaker. Slightly wash down the sides with distilled water.

2. Add 10 ml of mixed acid, 1 part Perchloric Acid and 4 parts Nitric Acid. Also, add 2 boiling chips.

3. Place on a hot plate and cover the beaker with a watch glass. Heat the sample until heavy nitric vapors are formed.

4. Then add 2-3 drops of Hydrofloric Acid and evaporate down to ± 2 mls.

5. Add 10 mls concentrated Nitric Acid and acid leach for approximately 10-15 minutes.

6. Wash down the sides of the beaker and watchglass with distilled water and allow to cool.

7. Filter the sample through a Whatman #2 Filter Paper and then dilute the sample to 1 liter, using distilled water.

ATTACHMENT 9-6

BACKGROUND RADIUM-226 LEVELS IN SOILS IN VICINITY OF JACKPILE-PAGUATE MINE

Sample Location	Radium pCi/g
Northeast Corner of Lease	0.37
North Lease	0.74
Woodrow Peripheral	0.56
Northeast Lease	0.71
Gavilan Mesa	0.81
Southeast Lease	1.90
#4 JP Well	0.10
North Lease (Near Hamilton)	0.32
West of Rabbit Ears	0.11
West Corner of Lease	0.15
North Oak Canyon Mesa	0.39
North Oak Canyon Mesa (above shop)	0.77
Oak Canyon Mesa (south of shop)	0.20
Oak Canyon Mesa (southeast of shop)	0.40
South Oak Canyon Mesa	0.14
Black Mesa Flux Site #4	0.38
Black Mesa (west above shop)	0.22
Black Mesa (above P-10 Vent #1)	0.10
West of South Paguate Pit	0.08
Northwest of South Dump	0.12
Gamma Survey Control Grids	
North Lease	0.10
North Oak Canyon	0.20
Northeast Lease Corner	0.58

Note: Samples taken 10-16-79 except those from gamma survey control grids, which were taken 4-20-79.

METHOD FOR DETERMINING RADON FLUX

3.2.3 Monitoring Procedure

Two basic monitoring methods, with several possible variations on each, have been considered for use at Jackpile-Paguate. Method I incorporates features of the techniques used by Kraner, et.al., (1964) and Bernhardt, et.al., (1975). Their flux determinations are derived from radon and progeny activity measurements of radon samples withdrawn at short time intervals from large containers sealed into the ground. It is assumed that the radon concentration buildup in the containers (and therefore the samples) is linear with time, since the total sampling times are short compared to the half life of radon (3.8 days).

3.2.3.1 Method I — *This is the Method presently used*

Method I requires a 55-gallon (209 liters) open-ended, modified steel drum whose open end is sealed into the ground for Rn collection (Bernhardt, et.al., 1975). This container is depicted in Figure 3.1. The container has two attached vacuum valves. The top valve (vent valve) is opened before the container is sealed into the ground and remains open during radon collection. This open valve is necessary to maintain gross pressure equilibrium with the free atmosphere (Kraner, et.al., 1964). The other valve remains closed until sampling. Exterior portions of the container are wrapped with 2.5 cm of foam rubber which is in turn overlain with a "space blanket" (combination of aluminum and mylar). This insulation should limit temperature variations within the container to less than 2^{o} C (Kraner, et.al., 1964) noted the absence of Rn concentration gradients in similarly sized, aluminum coated, polyethylene containers during collection times of several hours. The presence of a fan within the container to insure uniform gas mixing is thus deemed unnecessary.

Fiberglass insulation is used 4" rating

A flat, continuous ground area with no large rocks should be found at the measurement station for container installation. The open end of the container should be placed against the ground and dry

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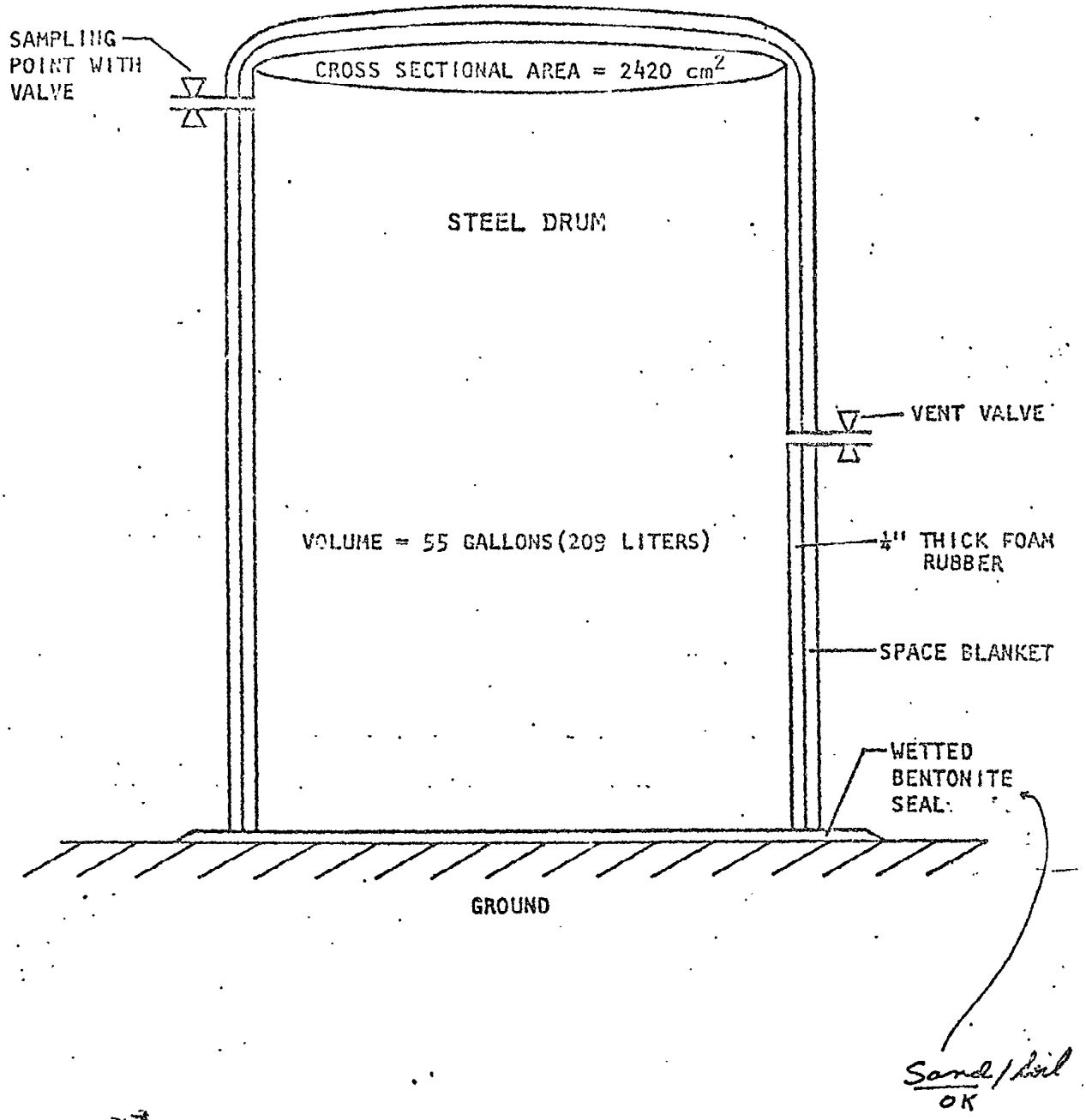

FIGURE 3.1 RADON COLLECTION CONTAINER

Sand or soil seal is acceptable seal according to Bernhardt (EPA) author of method, phone conversation

DAMES & MOORE

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soil used to seal

bentonite sprinkled around the container rim. The bentonite should then be moistned to provide a good wet seal. Sampling can begin four hours after installation to allow for a sufficient amount of radon buildup.

Air samples from the container are collected in 1.4 liter internally ZnS coated scintillation cells that have two attached vacuum valves (Eberline SC-6 Scintillation Cells). Sampling of the container air is accomplished by first attaching a scintillation cell, that had been previously flushed and sealed with aged nitrogen, to the container and pump as shown in Figure 3.2. Between the container and scintillation cell is a vacuum hose line containing a desiccant and a glass wool filter. The desiccant prevents water from entering the scintillation cell. The glass wool filter removes radon progeny from the sample gas being pumped into the cell. A battery powered pump with an attached flowmeter serves the purpose of pumping a known amount of sample through the scintillation cell. A sample is taken by opening all three valves on the line and then turning the pump on for half a minute with the flow rate adjusted to 10 liters/min. The pump is then shut off and the three valves closed. The scintillation cell is removed from the line (with both its valves remaining closed) and properly labeled with a sample number and the time of measurement. Samples should be taken at 45 minute intervals for three hours. The line should be detached after the series of sample measurements at a given station is completed. Three to five hours should elapse after sample collecting before counting is begun. This allows radon to almost reach equilibrium with its daughters in the samples (Eberline, 1977)

Sample radon concentrations can be determined via an Eberline SAC-R5 alpha scintillation counter (or equivalent) which feature a five inch diameter photomultiplier tube mounted face up in a light tight enclosure (Eberline, 1977). This is attached to an Eberline MS-2 portable scaler by a coaxial cable. In order to count a sample the room lights should be turned off and the coaxial cable discon-

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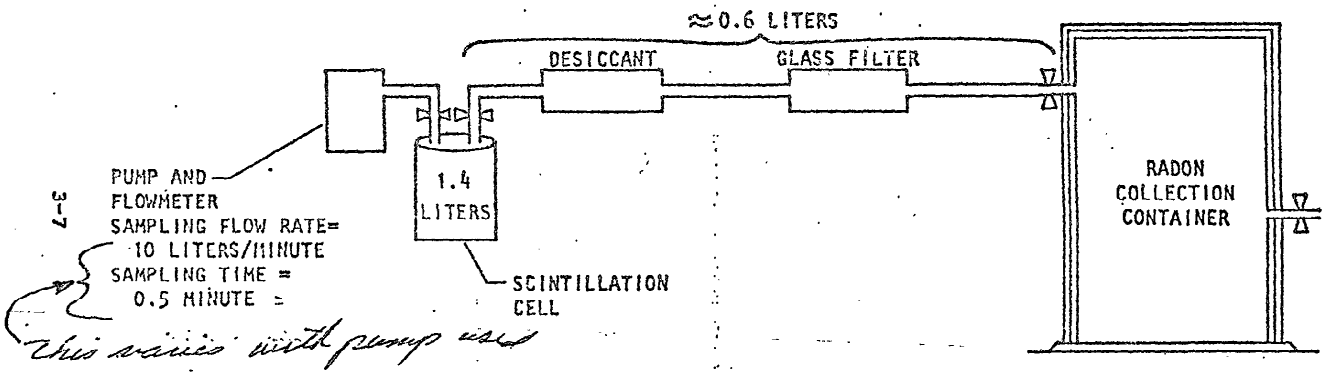

3-7

This varies with pump used

FIGURE 3.2 RADON SAMPLING APPARATUS

nected. A sample Rn scintillation cell is then placed into the detector chamber. After the removable chamber cover (μ metal shield) is replaced back onto the counter, the lights can be turned back on and the scaler reconnected. This procedure should be followed whenever a sample or standard is put in or taken out of the counter. The scaler should be set up for at least a thirty minute count for the sample cell. Upon completion of the reading the rest of the samples are to be counted. Prior to initiating the field sample collection, blanks should be run for thirty minutes on all cells which have been flushed and sealed with aged nitrogen. Background counting should be again performed on all used cells subsequent to aged nitrogen flushing for reuse. Upon completion of the sample and background counting, an Eberline DNS-4 certified Th-230 source should be placed in the counter on top of a piece of ZnS paper and a thirty second count performed. The observed counting rate should then be divided by the specific counting rate listed for the standard to provide a measure of quality control on detector electronics. If marked changes in these values are observed between counting sessions, recalibration of the system may be necessary.

Net measured sample activities are obtained by subtracting the appropriate background reading from each sample activity. Net measured sample activities in cpm can be converted to net measured Rn activity concentrations in units of pCi of Rn/l for the 1.4 liter cells by dividing these activities by 5.5. The conversion factor of 5.5, as calculated by the manufacturer of the proposed counting system, takes into account the counting efficiency, cell volume, and a correction for progeny disintegrations. These values are then plotted against the time after start of Rn accumulation in the container (in minutes). A best-fit line through the data is found by linear regression analysis (Bernhardt, et.al., 1975). The radon exhalation flux in pCi/cm^2-sec can be obtained from the slope of the best fit line (pCi/l-min) by the following relation:

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radon exhalation flux (fCi/cm^2-sec) = slope of the best fit line (pCi/min-l) $\times \frac{V}{Ac} \times \frac{min}{60\ sec} \times \frac{10^3\ fCi}{pCi}$

where V = container volume in liters

Ac = container cross sectional area (cm^2)

Site climatic conditions (temperature, barometric pressure, and precipitation) should be recorded from the nearest meteorological observation station for the entire period of radon collection. This information should be considered during the data analysis.

One possible variation in the above described method of determining radon exhalation fluxes is the use of a modified igloo cooler* instead of the steel drum. Igloo* coolers are 10 gallon cylindrical containers (approximately 19 inches in diameter) with faucet valves and are commonly used as water coolers. The hollow walls are constructed of aluminum and have plastic thermal jackets inside. The container can be adapted to Rn collection usage by adding another valve.

not used

Advantages of the cooler are that it is easily obtainable, requires less modification than the steel drums, and perhaps provides better insulation then the wrapped steel drum.

It may be found, especially in the case of smaller volume igloo coolers, that the open vent valve may cause a problem during sample collection. Outside air may be sucked through the container into the scintillation vial during sampling regardless of the wide spacing between the two container valves. This possibility should be investigated and it might perhaps be necessary to leave out or close the vent valve on the modified igloo cooler.

Method I can be summarized to consist of the following consecutive operational steps for a given station:

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1. While still in the laboratory aged nitrogen should be flushed through and sealed into the 1.4 liter scintillation cells to be used for sampling and background should be measured with a thirty minute count following procedures outlined in steps 12-16.

2. A flat, continuous ground area with no large rocks should be found at the measurement station for container installation.

3. The open end of the container should be placed against the ground and dry ~~bentonite~~ soil sprinkled around the container rim. The container rim should not be "shoved" into the ground and site disturbance should be kept to a minimum.

4. The ~~bentonite~~ soil should be moistened to provide a good wet seal.

5. Sampling of the container should begin four hours after installment. The time at which the container is installed should be recorded.

6. Attach a scintillation cell, vacuum hose, desiccant, filter, bilge pump, and flow meter as shown in Figure 2.2. All these valves (sampling valve on container, two scintillation cell valves) should be closed.

7. Open all three valves and then turn on the pump for half a minute. The flow rate should be adjusted to 10liters/minute.

8. Shut off the pump and then close the three valves.

9. Detach the scintillation cell from the line and label it with the proper sample number and measurement time.

10. Repeat steps 6-9 at 45 minute intervals for three hours.

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11. The samples should sit undisturbed for three to five hours after collection before counting is attempted.

12. Counting is accomplished in the laboratory with an Eberline SAC-R5 alpha scintillation counter attached to an Eberline MS-2 scaler by a coaxial cable (or equivalent).

13. In order to count a sample the room lights should first be shut off and the coaxial cable disconnected.

14. A sample radon scintillation cell (containing aged nitrogen) is then to be placed int the detector chamber. After the removable chamber cover is replaced back onto the counter the room lights can be turned on and the scaler reconnected.

15. The lights should be turned off and the scaler reconnected whenever a scintillation cell or standard is put in or taken out of the counter.

16. The sample cell should be counted for ~~at least thirty minutes~~ (2) two twenty (20) minute counts. Upon completion the rest of the samples are to be counted by the same procedure.

17. Each sample cell following counting should be flushed and sealed again with nitrogen, Thirty minute counts should then be performed to determine background cell activities for the next run.

18. A quality control on detector electronics is checked by placing an Eberline DNS-4 certified Th-230 source in the counter on top of a piece of ZnS paper and performing a thirty second count. The observed counting rate should be divided by the specific counting rates listed for the standard. If large changes in this value are observed between counting sessions, recalibration of the system may be necessary.

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19. Net measured sample activities are obtained by subtracting the appropriate cell background reading (cpm) from each sample activity (cpm).

20. Net measured sample activities in cpm can be converted to net measured Rn activity concentrations in units of pCi of Rn for the 1.4 liter cells by dividing these activities by 5.5.

21. The Rn activity concentrations should be plotted against time after start of the radon accumulation in the container (in minutes).

22. A best-fit line through the data is found by linear regression analysis.

23. The radon exhalation flux in fCi/cm^2-sec can be obtained from the slope of the best fit line (pCi/l-min) by the following relation:

$$\text{radon exhalation flux } (fCi/cm^2\text{-sec}) = \text{slope of the best fit line } (pCi/min\text{-}l) \times \frac{V}{Ac} \times \frac{min}{60\ sec} \times \frac{10^3\ fCi}{pCi}$$

24. Site climatic conditions (temperature, barometric pressure, and precipitation) should be recorded form the nearest meteorological observation station for the entire period of Rn container collection. This information should be considered during data analysis.

3.2.3.2 Method II

Method II entails utilization of essentially the same apparatus used in Method I. It however involves taking only three consecutive samples at least thirty days after the collection container is installed into the ground. The method utilizes the fact that the time to sampling is sufficiently large that the ground exhalation rate (such as in fCi/sec) is approximately equal to the product of the activity

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ATTACHMENT 9-8

BACKGROUND RADON-222 EXHALATION RATES

JACKPILE PAGUATE MINE AREA

Site	Date	Rate $pCi/m^2/sec$
Black Mesa	2-6-79	<0.10
Black Mesa	9-19-79	4.49
West Rabbit Ears	3-14-79	0.84
West Rabbit Ears	9-24-79	0.84
Jackpile No. 4	12-20-78	5.21
Jackpile No. 4	7-19-79	3.74
Woodrow Area	12-29-78	3.10
Woodrow Area	9-10-79	4.41
N. Oak Canyon Mesa	12-21-78	0.17
N. Oak Canyon Mesa	9-6-79	1.21
S. Oak Canyon Mesa	2-7-79	0.26
S. Oak Canyon Mesa	9-18-79	0.21
Gavilan Mesa	3-8-79	0.11
Gavilan Mesa	9-20-79	0.50
Northwest Lease Corner	3-12-79	0.25
Northwest Lease Corner	9-25-79	3.05
Gamma Survey Control Grids		
North Lease	3-16-79	0.29
North Lease	9-5-79	3.10
North Oak Canyon Mesa	3-20-79	2.71
North Oak Canyon Mesa	9-17-79	4.97
Northeast Lease	12-27-78	3.43
Northeast Lease	9-21-79	1.15